in the knowledge of the special subjects of the dissertations; for at some universities professors who have never published anything whatever are asked, as professors, to examine, for the doctorate, candidates with a European reputation! An instance of this nature has recently occurred in one of the universities in this country, the professors being almost unknown outside its walls. But no doubt Oxford and Cambridge may be trusted to stand above rendering such an injustice to those who seek their recognition and come from afar for the benefits they bestow.

British Crop Production.[1]

By Dr. Edward J. Russell, F.R.S.

Fodder and hay crops play a more important part than cereals in the economy of the farm, because they are the raw materials for a highly important part of the farmer's business—the production of meat, milk, or butter. They are too bulky to transport in any quantity, and farmers use only as much as they themselves grow. The output of meat and dairy produce is, therefore, limited by the quantities of these crops at the farmer's disposal. The quantities produced just before the war and in 1918 were:—

Production of Fodder and Hay Crops.

	Yield per acre 1908–17		Acreage. Millions of acres				Total produce. Millions of tons	
	England and Wales	United Kingdom	England and Wales		United Kingdom			
	tons	tons	1914	1918	1914	1918	1914	1918
Swedes	13·0	14·6	1·04	0·91	1·75	1·60	24·2	22·8
Mangolds ...	19·5	19·5	0·43	0·41	0·51	0·50	9·5	10·3
	cwt.	cwt.						
Hay (temporary)	29·1	32·2	1·55	1·45	2·90	2·80	4·2	4·4
Permanent grass	22·6	27·9	4·79	4·30	6·49	5·95	8·2	7·9

Like cereals and potatoes, these crops are greatly affected by artificial fertilisers, especially by phosphates, which increase not only the yield, but also the feeding value per ton. This is strikingly shown in the case of swedes and turnips, which receive a large part of the superphosphate made in this country. Mangolds respond remarkably well to potassic fertilisers and to salt. There is much to be learned from a systematic study of the influence of artificial manures on the composition and feeding value of these crops under the varied conditions of this country.

A further reason for the important part played by these crops in the economy of the farm is that they profoundly affect the fertility of the soil. They do not remove from the soil all the fertilising constituents which must be added to secure maximum growth; some of these constituents are left behind in the soil to benefit the next crop—a rare instance of double effectiveness for which the farmer ought to be profoundly thankful. In the second place, even the fertilising constituents which are absorbed by the crop are not entirely retained by the animal; considerable quantities are excreted and pass into the manure, and again are added to the soil. There is, therefore, the possibility of constant improvement of the soil; larger fodder crops enable more livestock to be kept, more livestock make more manure, and more manure gives still larger crops. It is sometimes argued that meat or milk production is in some way opposed to corn production, but on this method there is no antagonism; on the contrary, each helps the other. The production of more meat is consistent with, and indeed involves, the production of more corn.

The simplest way of utilising animal excretions without loss is to allow the animals to consume the crop on the land where it grows, and this is frequently done excepting where the soil is so sticky as to become very unpleasant in wet weather. Sheep are the best animals for the purpose, as they are easily penned in by light hurdles, these being moved as each portion of the field is cleared; this folding is a common occurrence on the chalky and sandy soils of the Southern and Eastern Counties.

Bullocks are less tractable, and cannot be enclosed by light hurdles; they are, therefore, generally kept in yards, roofed in if possible, but oftentimes open. Sufficient straw is added to provide them with bedding and to soak up the excretions. In this way the fertilising constituents of the straw as well as of the food are returned to the soil.

In the case of dairy cows the treatment is rather different; they have to be housed properly in quarters which are sometimes palatial, and for hygienic reasons they are allowed but little bedding. Their manure is removed once daily—sometimes oftener—the primary object being to get it away without contaminating the milk. The investigations already referred to for which Lord Elveden provides the funds are now being extended to the dairy farm to see how far it is possible to save the manure without prejudice to the purity of the milk.

In the old days, when farmyard manure was the only manure and the old type of implements alone were available, farmers had to arrange their crops on a definite plan in order to get through their work and maintain permanently the productiveness of the land. There thus grew up a system known as the rotation of crops, which contributed very largely to the agricultural developments of the 'sixties, and ultimately became a rigid rule of husbandry strictly enforced over large parts of the country. Modern cultivation implements and fertilisers justify much more latitude, however, and no good farmer ought to be restricted in his cropping, provided, of course, that he maintains the fertility of his land. It is sometimes a convenience on the dairy farm to grow the same crop year after year on the same land, and the Rothamsted experiments show that this can be done, excepting only in the case of clover. With this exception there is no more need to have a rotation of crops than there is to have a rotation of tenants in a house. It is essential, however, that the land should be kept free from other competitors and from disease germs. Freedom from competition means the exclusion of weeds. In the old days this had to be effected by periodical bare fallows. Nowadays a different course is possible; modern cultivation implements worked by a tractor allow great scope for the suppression of weeds. There is, however, one crop that must be grown periodically to ensure the best results—clover or a mixture of clover and grass. Clover affords valuable food for cattle during winter, and it also enriches the soil in highly valuable nitrogenous organic matter. Much of this is the work of the plant itself, and could equally well be done by grass; but the enrichment in nitrogen is the work of bacteria residing in the nodules in the clover-roots, and is unique among the phenomena of the farm.

---

[1] Discourse delivered at the Royal Institution on Friday, February 20. Continued from p. 178.

Unfortunately, clover, unlike other crops, cannot be grown frequently on the same land, and, consequently, the farmer is unable to make as much use of it as he would like. Investigators have for many years been trying to increase the effectiveness of the clover organism, but without result. Inoculation of the soil with virulent strains has been tried, but it was unsuccessful in this country, although results are claimed in the United States. The problem has recently been taken up at Rothamsted, and one reason found for the previous failure. The organism has several stages in its life-history, one of which is a period of rest; some conditions favour a long rest, others a shorter one, and Mr. H. G. Thornton is endeavouring to find out how to increase the activity of the organism in the soil and ensure that its work shall be done. Attention is being devoted also to the causes of failure of the crop. The clover crop furnishes some of the most important problems in arable farming before us.

In the meantime, a working solution lies in growing an admixture of grasses with the clover. This reduces the risk of failure while considerably benefiting both soil and farmer.

A typical arable district is thus a busy region in which both farmers and workers are kept constantly occupied. The crops claim attention all through the year, and particularly in summer, while in winter the animals need attention. Four or more men can be regularly employed per 100 acres. An organised village life has developed, having distinctive characteristics of its own and presenting endless scope for the intelligent social worker.

Grass farming, on the other hand, stands out in sharp contrast with all this. The grass farmer puts his animals into the fields, and Nature does the rest; when they are fat he sells them to the butcher. It is essentially summer work; the winters are left free. As no man can long remain idle, there has been an extensive development of hunting and its attendant occupation, horse-breeding, in the English grass regions. While the grass farmer's life is not all idyllic joy, it is, at any rate, free from much of the worry and uncertainty of arable farming, and it brings in sufficient money to ensure a modest competence. One can quite understand the reluctance of the farmer to quit this path of safety.

If one could accept the doctrine that a man could do what he liked with his land, the grass farmer could be left alone and reckoned among Virgil's too happy husbandmen. But this doctrine is now somewhat out of court, and the needs of the community have also to be taken into account. From this point of view grass husbandry, in spite of its safeness for the individual farmer, is not so good for the community as arable farming, since it is less productive per acre of ground. This was realised before the war, and was vividly brought to the notice of farmers by Sir Thomas Middleton, who drew up the following table :—

Number of Persons who could be Supplied with Energy for One Year from the Products of 100 *Acres of*

Poor pasture converted into meat	...	2–4
Medium pasture ditto	...	12–14
Rich pasture ditto	...	25–50
Arable land producing corn and meat	...	100–110

The area of rich pasture is very restricted. An improvement can often be made in poor and medium pasture by the use of basic slag, by drainage, and in other ways, but the results could probably never surpass those now obtained on rich pasture. None of them approach the results obtained on arable land.

During the war, therefore, the policy of the Food Production Department was to convert grassland into arable, and much was done; but now that the element of compulsion has disappeared some of the arable is going back to grass. It is not that the farmer is trying to avoid work; he is impressed by the greater risk of arable farming,[2] and, above all, he desires to keep to the well-established principle that his system of husbandry must suit the local conditions. This is strikingly shown by the following returns from a large number of farms :—

Collected by the Agricultural Costings Committee.

	Income per acre			Expenditure per acre			Profit[3] per acre			Capital per acre		
England and Wales—	£	s.	d.	£	s.	d.	£	s.	d.	£	s.	d.
Mixed farms ...	9	12	5	10	2	11	1	7	2	13	9	0
Dairy farms ...	14	17	0	13	18	5	1	7	4	15	7	0
Corn and sheep	7	7	1	7	4	10	1	14	2	12	10	9
Large sheep farm	1	4	3	0	17	6	0	8	5	1	7	10
All Scottish ...	5	10	9	4	15	10	1	4	11	7	7	9

The profit per acre from the large sheep farm is small in itself, but it is large in proportion to the capital and the expenditure, and, given a sufficient acreage, the farm is more lucrative than the more risky mixed or dairy farms. The risk of corn production can, and probably will, have to be met by some system of insurance or guarantee; but the need to conform to local conditions will always remain.

The problem therefore arises: Can a system of husbandry be devised which suits the natural conditions as well as grass, and is as productive of total wealth as arable crops? I believe this can be done. Grass is not the only crop adapted to moist conditions or heavy soils, and appropriate for the production of meat and milk. Many other leaf or root crops serve as well, some of which yield much more food per acre than does grass. Vetches, rape, mangolds, kale, and marrow-stem kale can all be used direct, and there are various mixtures of oats with peas, tares, vetches, etc., that can be fed green and made into hay or silage as the farmer may wish. The use of these crops in the place of grass for the feeding of livestock is known as the soiling system.

We are only just beginning to discover the combinations of crops best suited to particular conditions. An interesting experiment is in progress at the Harper Adams Agricultural College, which, however, should be repeated elsewhere. Each crop is governed by the same general laws as hold for cereals. In each case the yield and feeding value can both be increased by the proper use of artificial fertilisers, and there is the further possibility of great improvement by the plant-breeder.

It is in this direction that I think British agriculture will develop in the future. The system is strictly in accordance with the laws of science, and therefore it needs a minimum amount of artificial support. It gives the farmer abundant scope for the production of livestock, which he has always regarded as his sheet anchor, and the community an abundant production of food per acre. Most important of all, while

---

[2] On our ordinary farm at Rothamsted (distinct from the experimental land) the expenditure on arable land is continuously increasing, while that on the grassland is much less. The figures are :—

	1913-14			1917-18			1918-19	
	£	s.		£	s.		£	s.
Wheat	5	7	...	10	14	...	14	0
Oats	6	4	...	9	7	...	14	5
Roots	17	10	...	20	18	...	36	0
Potatoes	21	1	...	37	11	...	46	0
Grass (hay)	3	12	...	4	16	...	6	0
,, (grazing) ...	2	15	...	2	4	...	3	0

Direct wage payments account for about 40 per cent. of the expenditure on arable land, but for less than 15 per cent. of that on grassland.

[3] Including change in valuation.

retaining the best features of our present arable and grass systems, it allows of considerable further development.

I shall not venture any opinion as to how far we could go in feeding ourselves. The accompanying table shows what we did before the war, and what, on our present technical knowledge, we could do now, assuming that the insurance problem of covering the extra risks of arable farming were solved, and assuming also a reasonable increase in the efficiency of labour.

In this country we can certainly hope to find the solution of the insurance problem, and I hope and believe of the labour problem also. Our output per acre of the arable crops is distinctly above that of many other countries, though we no longer lead as we did in the 'sixties. Our output per man, however, is not particularly good, and is open to considerable improvement. Those who know the agricultural labourer best have the fullest faith that his sterling qualities will enable him to rise to the new levels of industrial capacity which the man of science and the engineer have opened out for British agriculture. There are anxious days ahead, but with wise and sympathetic treatment the difficulties can be solved and our future assured.

Consumption and Production of Human Food in the United Kingdom. Million Tons per Annum.

	Consumption (1909-13)	Home production		
		Pre-war	1919[4]	Estimated attainable
Wheat, barley, and oats	13·4	6·5	7·0	10·0
Other cereals	3·5	—	—	—
Potatoes	5·5	4·8	6·3	7·0
Dairy produce	5·2	4·7		5·0
Meat	3·0	1·8		2·5

---

[4] Mr. McCurdy gives the following details for 1919 (see *Times*, February 18, 1920):—

Consumption and Production of Food in the United Kingdom, 1919.

Commodity	Estimated total consumption	Proportion of home-grown and imported produce included	
		Home-grown	Imported
	Tons	Per cent.	Per cent.
Wheat	7,395,000	27	73
Barley	1,956,000	64	36
Oats	4,297,000	92	8
Beef and veal ...	995,000	66	34
Mutton and lamb ...	368,000	57	43
Bacon and hams ...	447,000	19	81
Butter	180,000	58	42
Cheese	145,000	30	70

Notes—Cereals: The quantities are given after deduction for seed, and in the cases of wheat for tailings also. Bacon: The quantities given are for bacon as smoked or dried.

Obituary.

THE death of M. LUCIEN POINCARÉ, Vice-Rector of the University of Paris, on March 9, at fifty-eight years of age, will be felt as a great loss, not only to higher education in France, but also to the *entente* between the universities of that country and those of Great Britain. Only a fortnight before M. Poincaré came to England, accompanied by Mme. Poincaré, to open the British branch of the Office National des Universités et Ecoles françaises, housed with our own Universities of the Empire Bureau in Russell Square. His speeches on February 23, at the Bureau, and on February 24, at the University of London, where he was given a special reception, and at the Lyceum Club, left on his hearers a deep impression of charm, of width of knowledge, of sound judgment, and of sympathy. M. Lucien Poincaré, like his brother Raymond, former President of the French Republic, and his cousin Henri, the great mathematician, came from Lorraine. He was a physicist by training, and took his doctor's degree with a thesis on the resistance of fused electrolytes. Like most French physicists, he began his teaching career in secondary education, and was a master first at the Lycée of Marseilles, and then at the Lycée Louis-le-Grand in Paris. For a time he was *chargé-de-cours* at the Paris Faculty of Sciences; later he entered on an administrative career and held successively the posts of Rector of the Académie of Chambéry, of Inspector-General and then Director of Secondary Education, and of Director of Higher Education at the Ministry of Public Instruction. In October, 1917, M. Poincaré was appointed official head of the University of Paris (the most distinguished post in French university administration) in succession to the veteran M. Liard.

THE death is announced, at sixty-four years of age, of PROF. HECTOR TREUB, the eminent professor of gynæcology in the University of Amsterdam.

THE death of MR. H. S. B. BRINDLEY is recorded in *Engineering* for April 9 as having occurred on March 28, only three days before his name appeared on the list of newly created Knights Commanders of the British Empire. Mr. Brindley was born in 1867, and educated at the Tokio Engineering College, where his father was an instructor. He had wide experience with several engineering firms, and will be remembered chiefly by his energetic development during the war of a disused artificial stone factory at Ponders End into a shell and gun factory employing more than five thousand hands, a task which could have been accomplished only by a very exceptional man.

BY the death, lately announced, of MR. W. J. RAINBOW, the Australian Museum of Sydney, New South Wales, has lost the services of an entomologist who for twenty-four years laboured with assiduity and success to make the collection of insects and Arachnida in that institution worthy of a great colony, and has thereby laid all students of those classes under a lasting obligation. Mr. Rainbow's published works include treatises on certain groups of Lepidoptera and Diptera; but his main attention was given to the study, and especially the life-history, of spiders and scorpions. His papers on Arachnida are sixty-seven in number, one of the latest being devoted to a description and classification of the Araneidæ brought from Macquarie Island by the expedition under Sir Douglas Mawson.